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Ethiopia

POTENTIALS OF THE BLUE NILE RIVER BASIN OF ETHIOPIA : ETHIOPIA GEODETIC PROJECT 1957 - 1961

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POTENTIALS OF THE BLUE NILE RIVER BASIN OF ETHIOPIA
ETHIOPIA GEODETIC PROJECT 1957-1961.

1. The magnificent resources of the Blue Nile River have long been recognized by the benignant rulers of the Abyssinian Highlands. For centuries they have studied the potentials of the river, but it was not until the reign of His Imperial Majesty, Haile Selassie I, Emperor of Ethiopia, that the development of the vast potentials for irrigation and power latent in the mountains and canyons of the watershed could be started. The watershed of the Blue Nile River includes over 300,000 square kilometers of west-central Ethiopia. The Blue Nile River has its source at Lake Tana in the Abyssinian Highlands at 1786 meters elevation above sea level. The river describes a semicircle on the high plateau and reaches the Ethiopia-Sudan border at 550 meters elevation and 850 kilometers from Lake Tana after passing through a gorge several hundred kilometers long, and at times approaching 30 kilometers in width and over a kilometer in depth. The gorge combined with the tributary gorges and mountainous character of the highlands provides unlimited numbers of sites for water resources developments.

2. The entire area is inhabited by agricultural people. The higher plateaus of the watershed are densely populated because of temperate climatic conditions and abundant precipitation. The extensive plains of the plateau and high valley provide thousands of square kilometers of rich soil. Important quantities of grains, hides, coffee, and other commodities are produced. Control of the abundant water supply for irrigation would increase agricultural production many fold and stimulate progress of the 5,000,000 farmers, herdsmen and artisians living in the watershed. The basic governmental and community structures exist to foster and promote physical development and to translate projects into personal income and public revenue. The development of the water resources of the Blue Nile River and tributaries in Ethiopia would provide power for industrial use and many essential factors in the continued growth and development of the country. Further, the use of the river waters for storage for power and irrigation in Ethiopia would not jeopardize other riparian countries.

INITIATION OF THE BASIN STUDY PROGRAM

3. The program initiated by the Imperial Ethiopian Government for the development of the Blue Nile River Basin was designed to provide an orderly and harmonious appraisal of resources to be followed by economically feasible physical developments. In 1956 Ethiopia concluded an Agreement with the United States for the study of the water resources of the area. In addition to a comprehensive water resources investigation and establishment of an Ethiopian Water Resources Department under the Imperial Ethiopian Ministry of Public Works, the program called for aerial photography and photomosaic maps plus precise geodetic control for use in the preparation of topographic maps. The agreement stipulated the contributions of both Governments, specifying technicians from the United States, and technicians, trainees and administrative personnel from Ethiopia. By a special agreement, the United States Coast and Geodetic Survey furnished 12 technicians to establish the precise geodetic control in the River Basin in accordance with approved geodetic standards and to provide on-the-job training in geodetic methods and procedures for Ethiopian nationals.

GEODETIC SURVEYS - PREREQUISITE TO RESOURCE APPRAISAL AND DEVELOPMENT

4. When Ethiopia initiated the Blue Nile River Basin program, basic geodetic control surveys and mapping were recognized as

required prerequisites of the water resources studies and subsequent physical development. Appraisals of resources cannot be rationally displayed and regional developments coordinated and economically pursued without basic surveys and maps. Accordingly, precise horizontal and vertical surveys were included. To be of maximum benefit, the surveys were required to be connected to the African Geodetic Datum and to mean-sea-level elevations to assure coordination of the program with present and future developments in adjacent areas and countries. The network of geodetic control in the basin was also designed to permit extension within the basin for large scale mapping for engineering works and throughout the remainder of Ethiopia.

5. An important feature of the geodetic program, significant to the aims of this conference, was the participation of Ethiopian technicians. A total of 60 employees of the Ministry of Public Works were assigned and after four years a nucleus of experienced Ethiopian geodetic surveyors remain capable of conducting precise surveys and capable of training other technicians in this important scientific field so essential to the development of Ethiopia and Africa.

CONDUCT OF GEODETIC SURVEYS IN ETHIOPIA

6. The geodetic control surveys in the Blue Nile River Basin were started in 1957 and continued without interruption until completion in 1961. A total of over 3,000 kilometers of arc triangulation and approximately the same length of spirit leveling was accomplished. The triangulation consisted of permanently marked stations spaced about 40 kilometers apart, supplemented by additional horizontal control stations for photogrammetry. The vertical control by spirit leveling established permanent bench marks at 3 to 5 kilometers spacing along the entire length of the leveling. All surveys were conducted using first-order methods and procedures. Taped and electronic base lines were used for distance control and astronomic latitudes, longitudes and azimuths for position control. With the cooperation of Sudan, connections were made to Sudanese surveys to provide horizontal positions on the African datum and vertical elevations related to mean-sea-level. A spur level line was also surveyed from the basin area eastward across Ethiopia to the Red Sea at Asseb completing a 4,000 kilometer leveling survey starting from the Mediterranean Sea at Alexandria, Egypt. The mean-sea-level of the Mediterranean Sea as carried by the surveys checked the mean-sea-level of the Red Sea by 0.18 meters.

STIMULUS OF TECHNOLOGY

7. Geodetic control surveys are frequently not awarded eminence commensurate with their importance to technological developments. Surveys are not an end product and are difficult to associate with the more evident and tangible phases of technological progress. However, control surveys must be used continuously from the first appraisal mapping for a development, through the planning and construction, and finally all during the span of its existence. In addition, basic geodetic control will decrease costs and expedite progress on contingent engineering and cadastral activity propagated by a resource development. The security of land tenure can be assured by land surveys tied to geodetic control. The mobilization of available internal potentials and the promotion of developed economy of an area is directly related to the status of the geodetic control and coordinated mapping in the area. The Ethiopian Geodetic Project of 1957 to 1961 contributed extensively to the development of the Blue Nile River Basin by establishing the surveys essential for the water resources inventory and appraisal. The control remains for further programs and concerted activity to increase the welfare of the area and the populace.

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Point de l'ordre du jour : A.3.4.1

France

L'ECONOMIE DE L'EAU :
LA LUTTE CONTRE L'EVAPORATION
DES NAPPES D'EAU LIBRE
DANS LES REGIONS ARIDES ET SUB-ARIDES,
EMPLOI DES GRANULES DE "STYROPOR"

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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

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L'ECONOMIE DE L'EAU

La lutte contre l'évaporation des nappes d'eau libre dans les régions arides et sub-arides

Emploi des granules de "Styropor"

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La croissance rapide de la population dans le monde, le développement accéléré de l'industrialisation dans de nombreux pays, l'accroissement constant de la surface des terres irriguées, (on en comptait 90 millions d'ha dans le monde en 1956), l'augmentation de la consommation d'eau individuelle, conséquence de l'amélioration des conditions de vie, ont pour résultat essentiel de faire croître dans d'énormes proportions les besoins en eau.

Devant ces besoins toujours plus grands, l'eau se fait de plus en plus rare et, face à la pénurie qui menace, il s'agit de découvrir de nouvelles ressources, d'utiliser de la manière la plus rationnelle possible celles dont nous disposons, d'en réduire au minimum le gaspillage, d'en éviter les pertes et d'en assurer le recyclage et la récupération.

Un des facteurs les plus importants de gaspillage et de perte est l'évaporation, elle même conditionnée par les températures de l'eau et de l'air, la turbulence et le degré d'humidité de l'air en contact avec la surface de l'eau.

Sous les climats chauds et secs, les pertes dans les systèmes de stockage et de distribution sont telles qu'une grande partie disparaît avant d'arriver à son point d'utilisation.

Comme c'est une grandeur qui échappe à l'observation immédiate, on ne se rend pas toujours compte de son importance réelle.

De plus, si les eaux usées industrielles peuvent, la plupart du temps être réutilisées au prix d'un traitement d'ailleurs plus ou moins onéreux, la perte par évaporation est définitive et fait sentir ses effets même dans les pays humides.

Les lacs naturels ou artificiels (barrages, réservoirs) qui constituent des réserves importantes d'eau, ont l'inconvénient de présenter une surface considérable à l'évaporation.

L'évaporation entraîne en outre une détérioration de la qualité de l'eau par la concentration de sels qui en résulte.

Les quelques chiffres suivants donneront une idée de l'importance du phénomène d'évaporation dans le monde.

En Tchécoslovaquie, les valeurs moyennes suivantes ont été relevées de 1956 à 1959.

Mois	Evaporation en mm
Avril.....	53
Mai	77
Juin.....	97
Juillet	89
Août.....	79
Septembre.....	57
Octobre	23

En Guinée britannique, l'évaporation annuelle s'élève à 140 cm.

A Burma, on estime que 110 à 150 cm d'eau sont perdus annuellement par évaporation dans les lacs, réservoirs, étangs..., la moitié de ces pertes s'effectuant en mars, avril, mai.

En Inde, dont le territoire s'étend en partie zone tropicale et en partie en zone subtropicale, l'évaporation peut atteindre en certaines régions 380 cm.

En Australie, l'évaporation qui s'élève à 254 cm sur la plus grande partie du territoire, dépasse nettement la pluviométrie sur les surfaces libres d'eau.

Au Japon, l'évaporation oscille entre 150 à 200 cm par an.

Dans la République Arabe Unie, sur les $5,3 \times 10^9$ m^3 stockés annuellement au barrage d'Assouan, 5×10^8 m^3 sont perdus par évaporation, tandis qu'au barrage Gabel Aulia, sur le Nil Blanc, près de Khartoum, d'une capacité de $5,5 \times 10^9$ m^3, environ $2,5 \times 10^9$ m^3 le sont également.

En Algérie, la tranche d'eau évaporée annuellement est presque toujours supérieure à la quantité de pluie tombée sur la même surface. Elle varie de 937 mm à Alger à 3.293 mm à Beni-Ounif, dans le Sahara occidental.

La lutte contre l'évaporation.-

Pour éviter, ou tout au moins diminuer les pertes, il suffirait de supprimer le contact direct de l'air et de l'eau. Dans cette perspective, on peut songer à stocker l'eau dans les réservoirs souterrains mais d'une part la vitesse d'infiltration est en général très faible, et d'autre part d'importantes pertes sont à craindre.

Un autre moyen de supprimer le contact de l'air et de l'eau est de répandre à la surface de celle-ci un produit susceptible de s'étaler en couche mince mono-ou multimoléculaire.

Cette propriété est commune à de nombreux produits solides ou liquides. Dès 1923, RIDEALS avançait que de telles substances étalées en couche monomoléculaire permettaient de réduire sensiblement l'évaporation d'une surface d'eau.

Plus tard, MANSFIELD démontra que les couches monomoléculaires se révélaient plus efficaces que les couches multimoléculaires dans la réduction de l'évaporation.

La propriété pour certains alcools, cétylique ou stéarique, de former des couches monomoléculaires provient de ce que chacune de leurs molécules est formée d'une chaîne hydrophile et d'une chaîne hydrophobe. Ainsi, lorsqu'une de ces molécules est mise en contact avec l'eau, l'attraction entre le groupe hydroxyle de la molécule et l'eau étant plus élevée que la force de cohésion des molécules d'alcool, celles-ci se séparent et ont tendance à former une couche très mince de molécules orientées.

Cette propriété dépend donc avant tout des forces de cohésion entre les molécules. Lorsque ces forces sont faibles, les molécules ont tendance à se déplacer à la surface de l'eau indépendamment les unes des autres et la cohésion est faible.

Par contre, lersque ces forces sont élevées, les molécules ont tendance à former une couche monomoléculaire cohérente et dans

ce cas, cette couche glisse à la surface de l'eau à la manière d'un liquide.

A l'état d'équilibre, la chaîne hydrophile plonge dans l'eau, et la chaîne hydrophobe se dresse hors de l'eau; dans ce cas, la couche monomoléculaire offre au passage de la vapeur d'eau une grande résistance tout en permettant le passage de l'oxygène et du gaz carbonique.

De nombreux composés organiques ont été étudiés à cet effet, mais c'est sur l'hexadécanol qu'ont été effectuées les principales recherches.

L'hexadécanol (ou alcool cétylique) de formule $CH^3(CH_2)^{14}CH^2OH$ est un solide blanc, gras au toucher, de point de fusion 45-51°, vendu sous forme de perles, de grains ou de plaques.

En contact avec l'eau, les radicaux OH de l'hexadécanol sont attirés par elle, les radicaux CH^2 étant tournés vers l'extérieur, l'étalement de l'alcool produit un film jusqu'à ce que la tension superficielle atteigne une valeur d'équilibre à partir de laquelle la dispersion cesse; cette tension superficielle est de l'ordre de 40 dynes/cm.

D'après MANSFIED, la vitesse à laquelle s'étale une couche d'hexadécanol est de $1,01 \times 10^{14}$ molécules par cm et par seconde, et le nombre de molécules nécessaires pour former un film est de $5,14 \times 10^{14}$ molécules par cm^2; on peut évaluer cette vitesse d'une façon différente, on trouve alors qu'elle est de 20 à 30 cm/s à 20°.

L'hexadécanol commercial contient d'autres alcools : tétradécanol, dodécanol, acides gras, qui gênent ou améliorent plus ou moins les performances de l'hexadécanol.

L'hexadécanol le plus efficace est fabriqué en Australie sous le nom de Si-Ro-Seal, sa composition est la suivante:

hexadécanol.....	80%
octadécanol.....	10%
tétradécanol et dodécanol...	5%
alcools non saturés.....	4%

Des études effectuées en Australie et aux U.S.A. ont montré que la résistance au passage de la vapeur d'eau augmente avec la longueur de la chaîne hydrocarbonée.

Par contre, la vitesse de formation de la couche monomoléculaire, qui dépend évidemment de la température, augmente quand la longueur de la chaîne diminue.

Les facteurs qui entrent en ligne de compte dans le choix d'un alcool gras sont :

- La vitesse de formation de la couche monomoléculaire

Elle dépend de la composition de l'alcool; on peut augmenter cette vitesse en ajoutant de petites quantités d'acide oléique (jusqu'à 10%). L'alcool en poudre donne une très bonne dispersion.

- La résistance du film à différents facteurs: insolation, vent, poussière, matières organiques.

La résistance du film à l'évaporation qui s'exprime en $g/cm^2/s$ et qui dépend de la composition de la molécule; l'addition d'agents tensio-actifs diminue cette résistance.

Le vent agit de plusieurs façons sur la couche monomoléculaire. D'une part, par son effet de refroidissement, il contrebalance l'action de la couche monomoléculaire qui provoque l'augmentation de la température de l'eau sur la couche elle-même et par suite une augmentation de la tension de la vapeur. D'autre part, il a une action néfaste sur le film; en effet les vagues ont tendance à augmenter la surface de l'eau en contact avec l'air et par conséquence à diminuer la tension superficielle de la couche monomoléculaire, cette tension peut tomber de 40 dynes/cm à environ 10 dynes/cm.

- Le pouvoir de rétablissement de la couche monomoléculaire après destruction par divers facteurs.

Un vent violent détruit la couche monomoléculaire; le pouvoir de rétablissement dépend de la nature de l'alcool ou des mélanges d'alcool utilisés.

On a constaté que les films formés à partir d'alcool en solution se rétablissent baucoup moins bien que ceux obtenus à partir d'alcool en poudre. Par contre, l'acide oléique favorise le rétablissement après destruction.

- Action de la couche sur la diffusibilité de l'oxygène de l'air dans l'eau.

Des mesures précises ont montré que l'hexadécanol provoque une légère diminution de la teneur en oxygène de l'eau. D'après nos essais, cette diminution serait de l'ordre de 12%. Il ne semble pas toutefois que cette diminution ait une influence néfaste pour la flore ou la faune aquatique.

L'efficacité d'un film dépend de son maintien à l'état liquide avec la tension superficielle maximale. C'est pourquoi les poussières, les matières organiques, les algues, qui ont tendance à "solidifier" le film, ont un effet néfaste sur lui.

- Toxicité.

Des études systématiques ont été faites en Australie et aux U.S.A. sur la toxicité de l'alcool cétylique vis-à-vis des poissons, des plantes aquatiques, du gibier d'eau; il semble que l'hexadécanol favorise le développement des bactéries telles que Pseudomonas et les flavobactéries; aucun effet n'a été observé sur les poissons, et les larves de moustiques ne sont aucunement affectées par la couche d'hexadécanol.

Jusqu'à ces temps derniers, ce sont surtout les Américains et les Australiens qui se sont intéressés au problème de la réduction de l'évaporation à l'aide d'hexadécanol. Au cours de ces dernières années, des essais ont été entrepris en Algérie, sous l'égide du Groupement de Recherche pour l'Application de la Chimie des Eaux (GRACE), d'une part en laboratoire, d'autre part à l'air libre sur des bacs de faibles dimensions et sur des bassins de 100 m^2. Les résultats n'ont pas été très encourageants. En effet, les gains sont très faibles, et l'économie réalisée n'est pas en rapport avec le prix de revient (achat du produit et main-d'oeuvre). On ne peut compter en définitive que sur une réduction de l'évaporation de 1 à 2%.

En outre, même sur une surface relativement faible, l'action du vent est néfaste sur le film.

L'efficacité de la protection semble diminuer à mesure que la surface à protéger augmente. Très bonne sur des béchers de laboratoire, elle est médiocre sur les bacs et négligeable sur les bassins.

Pour expliquer ces différences, on peut invoquer le recouvrement incomplet de la surface, donc un mauvais étalement de la couche monomoléculaire. Il est possible que ce défaut provienne de la qualité de l'hexadécanol employé (produit fabriqué en France). C'est sans doute pour cette raison que les résultats obtenus en Algérie sont moins bons que ceux annoncés par les Américains et les Australiens.

Après une période d'essais de 15 mois, on peut cependant conclure que le recouvrement d'un plan d'eau par l'hexadécanol est sans effet sur la faune aquatique. Par contre, ce traitement favorise le développement des bactéries et la croissance des algues dans le réservoir.

Mais il existe un autre moyen, depuis longtemps connu dans l'industrie, de lutter contre l'évaporation, c'est le recouvrement de la surface du liquide à protéger par une couche de petites sphères creuses en matières plastique.

Ce procédé se montre extrêmement efficace dans la lutte contre l'évaporation dans les réservoirs d'essence.

Appliqué à l'eau, il semble devoir apporter une aide sérieuse dans la lutte contre l'évaporation.

Le matériau utilisé est le "Styropor", polystyrène expansible utilisé dans la fabrication des matériaux légers. D'après nos essais préliminaires, ce polystyrène est un produit remarquablement résistant au vieillissement, à l'eau, à la moisissure, aux agents chimiques, et d'une très bonne imperméabilité à la vapeur d'eau.

Il peut être aisément transformé en matériau cellulaire de poids spécifique variable; le volume est constitué par 97 à 98 % d'air, ce qui explique ses exceptionnelles propriétés isolantes.

Comme pour l'hexadécanol, les essais ont été effectués au laboratoire, sur des bacs de 0,70 m^2 et sur des bassins de 100 m^2.

Essais au Styropor.-

Essais en Laboratoire -

L'étude a été effectuée en utilisant des béchers d'un litre de capacité, de 78 cm^2 de section droite, placés dans une étuve et pesés périodiquement et avec deux qualités de Styropor, de densités différentes.

Bécher n° 1. Surface de l'eau en contact direct avec l'air.

Bécher n° 2. Surface de l'eau recouverte par une plaque de Styropor.

Bécher n° 3. Surface de l'eau recouverte par une couche de 10 mm de perles de Styropor (densité apparente 180 g/l).

Bécher n° 4. Surface de l'eau recouverte par une couche de 10 mm de perles de Styropor (densité apparente 290 g/l).

Ces essais, d'une durée d'un mois, ont été effectués aux températures 30°, 43°, 66°, 75°, et sont résumés dans le tableau suivant :

Température 30°C	% d'eau économisée
dans Bécher n° 2	49,4
- n° 3	44,2
- n° 4	43,2

Température 43°C	% d'eau économisée
dans Bécher n° 2	77,7
- n° 3	69,7
- n° 4	69,0
Température 66°C	**% d'eau économisée**
dans Bécher n° 2	71,8
- n° 3	70,2
- n° 4	70,0
Température 75°C	**% d'eau économisée**
dans Bécher n° 3	64,1
- n° 4	70,8

Pour étudier l'influence de l'épaisseur de la couche de Styropor, les mêmes essais ont été effectués en recouvrant la surface de l'eau de perles de Styropor en couches de 20 et 30 mm d'épaisseur.

Dispositif d'essai

Bécher n° 1. Surface de l'eau en contact avec l'air.

- n° 2. Surface de l'eau recouverte par une couche de 20 mm de Styropor à 180 g/l.
- n° 3. Surface de l'eau recouverte par une couche de 30 mm de Styropor à 180 g/l.
- n° 4. Surface de l'eau recouverte par une couche de 20 mm de Styropor à 290 g/l.
- n° 5. Surface de l'eau recouverte par une couche de 30 mm de Styropor à 290 g/l.

Les résultats de ces essais sont résumés ci-après.

Température 30°C	% d'eau économisée
dans Bécher n° 2	45,3
- n° 3	46,9
- n° 4	45,2
- n° 5	46,3
Température 43°C	**% d'eau économisée**
dans Bécher n° 2	70,7
- n° 3	72,5
- n° 4	70,6
- n° 5	71,4
Température 66°C	**% d'eau économisée**
dans Bécher n° 2	72,2
- n° 3	73,4
- n° 4	71,7
- n° 5	72,9
Température 75°C	**% d'eau économisée**
dans Bécher n° 2	72,2
- n° 3	75,8
- n° 4	71,5
- n° 5	75,5

Dans ces essais effectués en étuve, en atmosphère immobile, seule la température intervient dans le processus d'évaporation. Un facteur important de ce phénomène étant le renouvellement de l'air à la surface de l'eau, pour en tenir compte les essais suivants ont été effectués à l'air libre.

Bécher n° 1. Surface de l'eau en contact direct avec l'air.

- n° 2. Surface de l'eau recouverte d'une couche de 10 mm de Styropor à 290 g/l.
- n° 3. Surface de l'eau recouverte d'une couche de 20 mm de Styropor à 290 g/l.
- n° 4. Surface de l'eau recouverte d'une couche de 30 mm de Styropor à 290 g/l.
- n° 5. Surface de l'eau recouverte d'une couche de 10 mm de Styropor à 180 g/l.
- n° 6. Surface de l'eau recouverte d'une couche de 20 mm de Styropor à 180 g/l.
- n° 7. Surface de l'eau recouverte d'une couche de 30 mm de Styropor à 180 g/l.

Les résultats obtenus sont résumés ci-après.

Pourcentage moyen d'eau économisée par la couverture de la surface :

dans le Bécher	n° 2..	61,5 %
-	n° 3..	63,3 %
-	n° 4..	63,8 %
-	n° 5..	56,0 %
-	n° 6..	57,0 %
-	n° 7..	58,5 %

On peut tirer de ces essais les conclusions suivantes:

- A température sensiblement égale, l'économie d'eau réalisée est plus élevée à l'air libre qu'en étuve.
- L'augmentation de l'épaisseur de la couche améliore légèrement le rendement.
- Le matériau le plus lourd semble donner les meilleurs résultats.

Essais sur bacs de 70 m^2 -

De même que pour l'hexadécanol, des essais ont été entrepris avec le Styropor sur des bacs de 0,70 m^2. Un bac a été recouvert par une couche de 10 mm de Styropor à 290 g/l.

Du 14 février 1960 au 30 juin 1960, les résultats suivants ont été obtenus.

Bac témoin; évapore 425 litres en 135 jours,
soit e = 2,2 mm/jour.

Bac recouvert de Styropor; évapore 67 litres en 135 jours,
soit e = 0,34mm/jour.

Le gain est de 84 %. Ce résultat est vraiment remarquable. La tenue au vent du matériau semble être satisfaisante. La couverture, repoussée par un vent assez fort, reprend sa position lorsque le vent diminue.

De plus, le produit ne semble pas être éparpillé par le vent, car dès qu'il est répandu sur l'eau, les perles de Styropor se recouvrent d'une légère pellicule d'eau et l'ensemble acquiert une certaine homogénéité.

Essais effectués sur bassins de 100 m^2 -

Devant le peu de succès de nos essais effectués avec l'hexadécanol à Relizane (Vallée du Chélif), ceux-ci ont été abandonnés, et l'un des bassins a été recouvert par une couche de 10 mm de Styropor à 290 g/l.

Les essais ont donné les résultats suivants:

Bassin A témoin; évapore 44.610 litres en 85 jours,
soit e = 5,2 mm/jour.

Bassin B traité; évapore 24.090 litres en 85 jours,
soit e = 2,8 mm/jour.

soit un gain de 54 %.

A l'échelle d'un bassin de 100 m^2, le vent ne semble pas avoir une grande influence sur la couche de protection; lorsqu'il est assez fort, celle-ci est légèrement comprimée contre les parois du bassin face au vent, mais toutefois, le bassin reste couvert par une légère couche assurant quand même la protection au moment où sous l'action du vent l'évaporation est nettement activée.

Lorsque le vent cesse ou diminue d'intensité, la couche se remet en place d'elle-même et assure la pleine efficacité de la protection.

Il y a évidemment une précaution à prendre, c'est d'éviter de répandre le Styropor par un jour de vent, car le produit avant d'être mouillé est très léger; il est recommandé de l'humecter avant de le répandre.

Les résultats ainsi obtenus expérimentalement paraissent encourageants, et bien plus probants que ceux fournis par l'emploi de l'hexadécanol. Une économie de 54 % a été obtenue. Il faudrait poursuivre les essais sur de grandes surfaces et étudier le comportement du produit au vent.

Le Styropor présente encore d'autres qualités: sa résistance vis-à-vis de l'eau et des microorganismes, son absence

d'odeur, sa couleur blanche qui réfléchit les radiations solaires et permet un contrôle facile de la continuité de la couverture. Il suffit d'étaler une fois pour toutes le produit sur la surface à protéger, et il n'est pas nécessaire de procéder, comme avec l'hexadécanol, à une distribution continue ou discontinue ou à des vérifications, peu aisées, de la présence du film.

Dans les régions arides ou sub-arides, où l'intensité de l'évaporation interdit souvent la construction de réserves d'eau qui deviendraient facilement "autophages", l'emploi de ce moyen de protection, aisément maniable, devrait faire l'objet d'études et d'expérimentations plus poussées, afin de parvenir à une juste appréciation de l'économie du projet.

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APPROACHES TO AN ENERGY POLICY IN A DEVELOPING COUNTRY

By The Department of Economic and Social Affairs, United Nations, New York

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APPROACHES TO AN ENERGY POLICY

IN A DEVELOPING COUNTRY

A.4.1.

by

the Department of Economic and Social Affairs

United Nations, New York

I. Introductory remarks

1. The formulation of a policy for energy development raises a vast and complex set of problems which this paper cannot pretend to cover in a comprehensive way. It refers mainly to some of the issues emerging from the experience gained in United Nations Technical Assistance and related operations in developing countries, and, in particular, in those which are poor in energy resources.

2. An attempt will be made to point out what seems to be a necessary sequence of steps to be taken prior to the framing of an energy policy; the necessity for an integrated approach to energy problems covering mineral fuels and electricity, as well as the non-conventional sources of energy; the setting of goals consistent with the overall economic and social aims to be achieved; and finally the possible advantages of international co-operation in the field of energy development, especially in the case of smaller countries and those not richly endowed.

3. Energy plays a most important role in economic development since the extent to which it is available will either stimulate or impede the process of economic growth. And, in this respect, it is perhaps electric power which is the most important agent of both technological change and economic progress in developing countries. In most cases, the rate of electrification will set the pace for the development in all other fields of the economy. Because most of the engines and machines that turn out the goods of modern civilization are essentially means for supplementing human and animal energy with the immensely greater potential

of mineral fuels and water power, the differences in per capita national income are closely related to differences in per capita energy consumption. 1/

4. However, generalized statements on energy problems in developing countries may easily be misleading since conditions vary greatly from one country to another, both as regards resource endowment on the one hand, and the targets set and methods employed in the effort to develop the economy on the other.

5. The term "energy" used throughout the present paper should be understood to represent an abstract concept which may sometimes obscure the real issue and processes at play. The term "energy" is only a convenient abbreviation for what is after all a conglomeration of heterogeneous elements, such as hydro-power, coal, petroleum, natural gas and so on. Physical and economic characteristics of these energy sources differ greatly, and even where there are technical possibilities of substitution, they may not always be economically feasible.

6. The degree of availability of various indigenous energy resources will certainly be reflected in the national approaches to energy problems. While in a few countries one may find an abundance of coal, hydro-power, petroleum and natural gas, others may possess commercial quantities of only one of these resources. Finally, there is a number of developing countries which are very poor in any known kind of domestic energy resources.

7. On the demand side, while in some countries the emphasis is clearly on industrialisation on a broad front, in others the development of agriculture and primary industries may take precedence. The pattern of development will greatly influence energy requirements and energy policies.

II. Prerequisites for energy policy formulation.

a) Estimates of present and future requirements of energy

8. Prior to the formulation of an energy policy it is necessary to assess the national energy requirements and to compile an inventory of the known energy resources. In estimating energy requirements, it should be pointed out from the

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1/ Low per capita consumption of energy is a common feature of all underdeveloped countries. Expressed in kilograms of coal equivalent, in 1960, per capita consumption in Yemen amounted to 6 kilograms of coal equivalent, in Ethiopia to 8, Afghanistan to 14, Somalia to 24, Nigeria to 39, Sudan to 50, Pakistan to 67, India to 140, while in the United States it was in excess of 8,000 and the United Kingdom reached a consumption of almost 5,000 kilograms per head of population. (World Energy Supplies 1957-1960, Statistical Papers, Series J, No. 5, United Nations, New York.) Figures given as examples, however, generally understate the real energy consumption as they do not take into account the non-commercial sources of energy, which in some developing countries may contribute as much as two-thirds or even more of the total energy consumption.

very outset that the term "requirements" tends to be somewhat ambiguous and rather difficult to define. It is obvious that energy consumption is closely tied to economic growth and the proper starting point for estimates of future energy requirements is thus a consideration of the prospects for future economic growth.

9. While projections of past trends may prove reasonably useful in mature economies where a certain continuity of development might be anticipated, regression analysis or similar methods of projection in developing countries could easily be misleading because of:

i) the rather discontinuous character of economic development itself, implying profound structural changes;

ii) inadequacy of data for the past period.

10. In very broad terms, the assessment of energy requirements in a developing economy falls into two main categories:

i) evaluation of effective demand in the monetized (as opposed to the subsistence) sector of the economy, which can be quantified on the basis of an estimate of the requirements of the developing industries and transport, as well as household consumption in and around the existing nuclei of development;

ii) an assessment of "felt needs" (which are not yet backed by demand in the strict sense of the word, i.e., by existing or expected purchasing power) - which are very much a function of general plans for social and economic development of areas still predominantly of a subsistence economy type. The satisfaction of such needs will depend on the political and social goals set by the government as well as on the availability of capital over and above that earmarked for the already existing or projected centres of industrial expansion.

b) Inventory of known energy resources and facilities

11. The second preliminary to energy policy formulation is the preparation of an inventory of the utilised or known energy endowment as well as the existing processing and distribution facilities in the energy sector of the economy.

12. An assessment or evaluation of energy resources on a national scale may be undertaken for either one or both of two purposes. The first purpose is an immediate one: to identify (that is to find and measure) resources that are or can be economically exploited under present conditions. Such an activity is normally the function of an agency like the Geological Survey or Hydrological Survey and is of special importance in developing countries. The second purpose of energy resource evaluation may encompass the first but has as its main focus the long-term future. This purpose is assuming increasing importance all over the world as greater attention is given to long-range programming with the improved techniques for undertaking it.

13. The first kind of inventory should, of course, be considered as an urgent task, particularly in those countries where data on resource use are scanty. This inventory should provide at least a minimum of technical and economic information on which to base forward planning.

14. The basic data required should include:

i) for hydro-power: the known power potential, installed capacity, size of units, location of power plants, the output and its seasonal variations, cost, degree of utilisation and stand-by capacity and technical characteristics of equipment;

ii) for coal and lignite: known reserves, capacity and location of mines, output, cost and utilisation;

iii) for petroleum and natural gas: proved reserves, location, output, quality, cost and utilisation. Similar data should be assembled for geothermal energy, if present.

15. In addition, it would be useful to have some information on non-commercial sources of energy, such as wood, straw, dung....., particularly in the household and agricultural sectors.

16. Data should also be compiled on the various energy processing plants, such as thermal power stations, petroleum refineries, coal washing plants, gas works, etc., covering the capacity of plants, location, load factors and costs, as well as the organisation of the power systems.

17. The inventory should contain information on existing electric power transmission lines and distribution systems, on pipelines (capacity, length, utilisation and cost), on railway lines and the cost of transport per ton of coal or petroleum, on the costs of transport of fuel by road and on natural gas distribution systems.

18. Furthermore, it is necessary to make an analysis of available energy end-products within the country, including an analysis of costs to consumers in different regions. In this context, information is also required on imports of energy products (or exports if any), their cost (or earnings) in foreign currency, their costs to consumers (c.i.f. prices plus taxes, transport and distribution costs within the country).

III. Stages of Energy Development.

19. The development of energy supplies basically involves five stages: a) energy exploration; b) the expansion of primary energy supply; c) the provision of energy-transport facilities; d) the construction of energy-processing facilities, if needed; and e) the establishment of distribution facilities.

a) Energy exploration

20. General geological exploration and mapping of surface indications is a necessary long-term task providing basic multi-purpose information. The proving of energy reserves, however, involving as it does, in the case of fuels, drilling and many other capital-intensive activities, is a matter which should be determined, as to its intensity, timing and scale, by the energy needs of a country within the context of the overall economic development programme. In other words, a country which already disposes of well located known energy resources of high quality for fifteen or more years to come should not consider capital-intensive exploration as a task of high priority.

b) Expansion of primary energy supply

21. The point just made is of even greater relevance when considering the development of a mine, petroleum or steam field, or hydro-power site. Heavy initial investment is sometimes undertaken on the erroneous assumption that once the primary source of energy becomes available, subsequent stages will be more easily financed. Such reasoning can lead, for example, to the construction of hydro-power stations which cannot be put into operation because no provision, or inadequate provision, has been made for the construction of transmission lines.

22. It is also important to attempt to determine in advance the probable cost of the power supplies to be developed. While energy costs vary considerably, and what is acceptable ranges fairly widely, it is useful to compare the estimated costs with a typical range so as to judge whether they are likely to be economic. 2/ When considering the investment requirements for hydro-power, it is not enough to take the figure for costs per kilowatt of installed capacity; it is also necessary to consider the volume of output - the kilowatt-hours to be produced per kilowatt of capacity, which will depend on the storage, flow characteristics of the river, and similar factors. 3/

c) Provision of transport facilities

23. In transportation, the economies of scale have considerable significance. Large quantities, and only large quantities, can be moved economically over comparatively great distances. This is basic for all energy supplies and applies to pipelines, transmission lines, railways and tankers. 4/ Transportation of coal and oil is generally most cheaply effected by water transport, followed by pipelines, railways and trucks, in descending order; the means of transport usually

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2/ In coal development, an investment range of up to $10 per ton of annual capacity is considered low, $10 to $20 reasonable, and over $20 as high - taking into consideration, of course, the quality of the coal, its location and similar factors. Investments of more than $40 or $50 per ton have, nevertheless, been known to be made, and they resulted, needless to say, in very expensive coal.

3/ For a large hydro-power plant with an average utilisation of, say, 5,000 hours a year hydro-power will be very cheap if the investments per kilowatt are to amount to less than $100; fairly cheap if they are to be less than $200; reasonable if they are to be $200 to $400; high if they are to exceed $400. A small micro station may cost as much as $800 per kilowatt; but on the other hand it may require practically no other investments. If it can be expected to operate at a reasonable or high utilisation factor, the investment may be well justified. Similar key data are available for geothermal and other sources of energy. They offer a useful yardstick for measuring probable costs of primary energy supplies.

4/ Electric power generated by a 10 MW station can only be economically transmitted within a 50-80 kilometre radius. Small energy deposits and small power plants can be economically utilised only on a local level.

being determined by the distance and topography involved. While keeping in mind specific local conditions, programming of energy transport facilities should be based on the available data on typical cost and time requirements for each form of transport.

d) Construction of energy-processing facilities

24. Space does not permit a thorough discussion of thermal power plants, refineries, coking and briquetting plants. However, it may be mentioned that it takes three to four years to build a central thermal power station and at least two years to add more plant to an existing station. 5/ The time required for the construction of a small refinery usually varies between 18 and 24 months. 6/

e) Establishment of distribution facilities

25. Distribution facilities for electricity may be very capital intensive. Where electricity is sold to a large number of small consumers spread over a considerable area, the distribution network may require more capital than was required for generation and transmission. The same applies to the distribution of gas and, to a lesser degree, to petroleum products. Capital requirements for distribution are, therefore, a subject which should be carefully scrutinised.

IV. Decisions and Choices

a) Framework - the overall development programme

26. In developing countries, economic programmers operate under conditions of extreme scarcity as well as under pressure of urgency. Claims on capital are manifold and only a minor share of investment may be earmarked for the energy sector. 7/ Furthermore, energy development will have to be closely co-ordinated

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5/ Capital cost of building a conventional thermal plant will range from $100 to $250 per KW installed. At least as much has to be invested in transmission and distribution facilities.

6/ A refinery with a throughput of one million tons a year will today cost 30 - 40% less than it would have done a few years ago - which is another result of technological progress from which developing countries can benefit.

7/ In India, where much more attention is paid to the development of energy resources than in most other developing countries, about 7 per cent of total investment in the Second Plan and 10 per cent in the Third Plan were allocated to electric power. The allocations for petroleum and coal were considerably lower than those for power development.

with the requirements of other sectors, in particular with those of industry and transport.. In fact, a slight excess of energy supplies over anticipated requirements will probably prove to be a precondition for a smoother implementation of overall development programmes, since a shortage of energy will delay the fulfillment of other planned objectives. It is, therefore, recommended that a certain amount of reserve energy capacity should be provided for; although, in so doing, care should be taken to avoid tying up scarce capital in investment which may not be fully utilised. On the other hand, when deciding on the development of industries, it should be kept in mind that the most capital intensive are usually also the most energy intensive. As the means for the development of an energy basis tend to be limited, there is a very strong case for good husbanding of energy resources. This is not necessarily to imply that a policy of natural resource conservation should be adopted, since other resources (such as capital) may be even more limited, but rather to suggest that when faced with a choice of different types of industries, preference might be given to those which will be capable of operating economically with more modest energy inputs. However, this recommendation should not be applied inflexibly. For example, when faced with a possible excess capacity of cheap hydro-power and the availability of, e.g., bauxite, there should be no reason not to develop an energy-intensive industry as that of aluminium.

27. As already mentioned, the overall development programme will also have to determine the amount of capital to be made available for the development of an energy infrastructure, in particular in those parts of a developing country which are still without any electric power supply and continue to live within a framework of subsistence economy. Investment in energy infrastructure, especially in that of electric power, will create external economies for other sectors of the economy - but it is very difficult to measure or predict its possible returns. Provision of power for future regional centres (with hospitals, schools, repair shops, etc.) in backward and remote areas may prove to be an important catalyst of economic development, creating new jobs, diversifying the economy and also creating skills for industrial development at a later stage. The decision on how much to invest in such projects will be largely based on political and social considerations. Thus, the energy programmer has to operate under a set of constraints resulting from the general economic policy of his country. These will determine the amount of capital and of foreign currency at his disposal as well as the general priorities he will have to comply with, such as the industries which will have to be provided with power, the areas to be electrified and so on. Within the framework of these constraints, he will still be faced with a number of choices and decisions. These will involve technological and economic considerations in respect of the choice among different types of energy resource and end-products; timing of projects; size of plant and economies of scale; problems of location and transport; degree of capital intensity; possibilities of saving foreign currency, as well as problems of pricing rates, taxation, etc.

b) Technical progress

28. Despite all their difficulties, the countries now embarking on economic development start from a better initial position than did the presently developed

countries, and this is perhaps particularly so in regard to energy, in so far as they can make full use of technological progress of the last half century. They will benefit, for example, from a more efficient use of primary energy in power production, from new techniques for the improved utilisation of power, and last but not least they will have at their disposal not only a number of new sources of energy but also some recently developed cheaper forms of small-scale energy production.

c) Applicability of market criteria

29. It is open to question whether the problem of energy programming can be rationally undertaken only in terms of costs and profits of individual enterprises, i.e. whether one can exclusively rely on market criteria. Profitability from a market point of view should not be the only criterion for investment which has as its purpose the creation of external economies for other sectors of the economy, and above all for the infant industries. In fact, a whole cumulative expansion process has to be blue-printed in terms of investment projects and their effect on the volume of production, on consumption, on employment of workers and natural resources, and on health and productivity of labour in various sectors.

d) Timing

30. Faced with this complex process of planned economic development, the energy programmer has to devise the means of bridging the gap between the energy supplies available today and the requirements, say two, five or ten years hence. He has also to take account of the gestation period of different energy projects, the size of investment required, as well as the economic efficiency of the proposed solutions.

31. A shortage in the available primary energy supplies, for instance, might be overcome by the development of known local energy resources or by increased imports or by exploration for new or additional energy resources. The speediest method to increase the availability of primary energy supplies is obviously increased imports, but imported energy supplies always require foreign exchange and may raise a balance of payments problem. The development of known energy resources requires much more time, and again some of the known energy resources may not allow low-cost energy production; and exploration for new energy resources is obviously a very long-term undertaking. If means are available, it may be appropriate to adopt all three measures - providing for an immediate increase in supplies through imports; for further local production within a few years; and for large domestic supplies in the longer run through an active exploration programme. Thus, successful programming in primary energy resources development will depend in large measure upon proper timing factors in a given situation. Petroleum fields, for example, can be developed in a relatively short time span - a field can be put in operation in one or two years. A coal mine, however, unless it is a surface mine, requires more time, usually between two and five years. Moreover, in underdeveloped countries, time requirements are usually somewhat greater. The construction of a hydro-power plant may require 4 to 8 years, but has been known to take more than 10 years in some cases. As the

development of a primary energy resource often lags behind energy requirements, it sometimes becomes necessary to resort to temporary means pending completion of more time-consuming energy-producing facilities. It is possible, for example, to use small diesel plants to bridge the gap until the completion of a hydro-power plant. 8/

e) Problems of scale and location

32. Despite encouraging progress achieved in reducing the costs of small-scale power production or in building refineries, economies of scale both in energy production and transportation are perhaps more important than in any other sector. A modern 275 MW thermal power unit compared with one of 30 MW has an approximately 40% better index of thermal efficiency, and capital costs per KW installed are also about 40% lower. Operating costs tend to decrease likewise. Relative costs of processing 1 barrel of crude oil in a simple refinery with a throughput of 500,000 tons per year are about 2.3 times greater than in a 4 million ton per year refinery. In transportation these trends are even more marked. A 275-kv transmission line may be 2.6 times dearer per kilometer than a 132-kv line, but its capacity will be 6.2 times bigger. The same general tendency applies to pipelines, tankers and so on. This would tend to show that concentrated development of energy resources in locations where demand is heavy would yield far better returns than wide-spread small-scale development. However, the economies of scale can only be derived where the rate of utilisation of equipment is high and, therefore, stress should be laid on determining the optimum scale of operations, especially since the conditions prevailing in most developing countries (with the exception to some degree of such large countries as India, Brazil and Pakistan) are not conducive to large-scale methods of energy development. The actual and even the prospective requirements will rarely warrant it and, in addition to this consideration, it should be recalled that there is also considerable pressure to expand the energy infrastructure of the country as widely as the available means permit. The energy programmer will, therefore, more often than not be called upon to strike some kind of a balance between the attractions of the economies of scale tending to concentration of production and to transportation in bulk, and the tendency to build a number of smaller installations as close as possible to the scattered minor centres of consumption. In any case, the

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8/ Experience has shown that, where in developing areas a beginning of public electric supply is warranted, a sound procedure is to install diesel generators, say, of 1,000 to 1,500 KW unit size. Owing to their limited cooling water requirements and low weight (reducing foundation problems) there is considerable freedom of siting. By the time the demand for power has reached, say 7/8,000 Kw, the future development and requirements of the area would be clearer cut and it should be possible to make a full economic study of the relative advantages of separate power stations with individual networks, or possibly a wider network with one major central steam turbine or hydro-electric station. If it should be decided to build such a central station the diesel generators could be picked up and installed in some other area where electric supply is beginning to be required. (Michael Hubbard: The Use of Oil in Developing Countries, Paper A17, World Power Conference, Belgrade 1957, p. 15)

programming of small isolated plants should be of such a nature as to permit integration into more comprehensive systems at a later date.

f) Capital and foreign currency requirements

33. Another important factor which tends to limit the size of projects in developing countries is the amount of capital required. For this reason there may be certain aspects of energy programmes which will have to be based on less costly solutions, which, from a technical point of view, may not be the most efficient. Moreover, the foreign currency component of almost all energy projects is usually very high. The proportion of equipment to total capital expenditure amounts to about three quarters for electricity supply undertakings, coke ovens, gas works and oil refineries. For collieries it usually approaches two-thirds. By far the largest part of this equipment will have to come from abroad and the foreign exchange component in the capital outlays for a thermal plant may easily amount to 80% or more of the total. In the construction of hydro-power plants this component will be considerably lower because of the large share accounted for by civil engineering work which may be undertaken by local personnel. Hydro-power plants permit a further saving of foreign currency since they reduce imports of fuel. However, in many cases these considerations will have to be weighed against the long gestation periods required for the erection of such power plants. Furthermore, in addition to the detailed study of capital and time requirements, careful attention should be paid to the cost per unit of output, which comprises both capital charges and operating costs. Capital charges are in turn a function of the amortization period, or life expectancy, of the various facilities to be installed. 9/ Capital requirements, therefore, are not a sufficient basis for valid economic comparisons. If the amortization period is taken into account, it will be found that a diesel plant, though involving a relatively small investment, will nevertheless produce expensive power, because it has to be amortized in a comparatively short period - 10 years - and also because it consumes a high-cost fuel. Because of the capital-intensiveness of energy industries, capital costs are often a factor of over-riding importance in energy programming. Refineries and pipelines operate economically only if their operation is continuous - day and night, and all year round - since their fixed costs constitute a very high percentage of total costs. If hours of operation drop from, say, 8 thousand hours to 4 thousand hours per annum, cost per ton is likely to jump four-fold. In coal mines, on the other hand, where wages constitute a relatively larger share of total costs, a curtailment of operations will not bring such a sharp cost increase. A developing country will thus need to consider very carefully the capital and foreign exchange implications and to balance the initial costs of alternative schemes against their subsequent operating costs.

9/ Hydro-power plants are amortized over 35 to 50 years; thermal power plants over 25 to 35 years; diesel plants over 10 years, refineries and pipelines over 15 years; wooden poles for transmission lines over 20 years; steel poles over a period of up to 50 years; railways over 25 to 40 years and so on.

g) Taxation and pricing problems

34. A rather sensitive area for policy decisions is the complex of pricing, rate setting and taxation. Though the price elasticity of demand for energy products in most developing countries tends to be rather low, experience shows that taxation may still have quite some impact on the patterns of demand. Therefore, both rate setting and taxation policies may constitute an important instrument for the government to orientate the development of energy resources in one direction or another.

35. A policy of cheap energy may have a stimulating effect on overall economic development. It has, however, to be balanced against the possible shorter term difficulties which may arise from a reduction of government revenue (in the form of taxes and duties on imported fuels or machinery, which in some cases represent a very substantial share of total government receipts), and it may also reduce the returns of energy undertakings, therefore rendering more difficult the payment of debt and other charges as well as postponing further the break-even point at which these undertakings would become profit bearing. All these considerations require very careful study and should be weighed carefully one against the other.

36. Another point in this context seems worth mentioning. Consideration should be given by policy makers to the possibility of evolving differential tariffs and rates so as to promote consumption by certain categories of consumers (such as industries enjoying a priority under the overall development plans or certain groups of population among which it is the government policy to encourage the utilisation of energy). Some thought may also be given to a rate structure designed to lighten the burden on the consumers during the first years, while the development process is only getting under way, with a view to increasing the rates progressively as the ability to pay becomes greater.

V. Need for a Centralized Agency Responsible for Overall Energy Policy

37. In spite of the integrated character of the various aspects of energy development, in many countries the different aspects of the energy economy are handled by a number of independent and unrelated authorities. One ministry will often be responsible for the mining policy, another for the imports of fuels, a third for power development and so on. The necessity for integrated thinking, integrated policy and even integrated and unified implementation of energy development plans has gained considerable recognition in recent years, however, and a number of developed countries have established unified central bodies to deal with energy matters, e.g. United Kingdom, France, Italy, Belgium.
An integrated energy policy and a unified authority over energy matters is even more important to developing countries. Such an authority should work closely with, or even be a part of, the body deciding on overall development policies.

VI. International Co-operation in the Development of Energy-Resources

38. Capital scarcity, lack of resource endowment, narrow markets which tend to preclude economies of scale and other factors hampering the development of an

energy basis in a developing country might, under certain conditions, be overcome or at least alleviated if neighbouring countries - or a number of countries within a region - were to pool their resources and attempt to co-operate in their development. The Mekong scheme, the Iron Gate project, the idea of co-operation in the use of natural gas in Asia and the Far East mentioned at the Second ECAFE Petroleum Symposium at Teheran, as well as a number of other schemes already in operation, seem to indicate that there is an increasing awareness of the mutual advantage to be gained by such co-operation.

39. The United Nations, the specialised agencies and related international organizations have made a considerable effort in assisting developing countries in the field of energy. 10/ A number of United Nations Technical Assistance experts have advised governments on energy policies and tariff problems as well as on specific technical matters. The Lower Mekong Basin development scheme in addition to similar undertakings now in the offing in Africa are being actively sponsored and co-ordinated by the United Nations and the specialised agencies. The United Nations Special Fund has provided assistance for a number of power surveys. In addition, the United Nations have attempted to train both technicians and administrators dealing with energy problems and have inter alia granted a number of scholarships to such persons. 11/ The International Atomic Energy Agency has promoted the application of nuclear energy by means of studies, conferences, technical assistance and other means. This Agency maintains close co-operation with the United Nations and joint Technical Assistance missions have been sent to a number of developing countries to investigate the possibilities of utilising nuclear power for energy development. The International Bank for Reconstruction and Development regularly undertakes general economic surveys and also investigates particular projects at the request of Governments in connection with the granting of loans. It is expected that these various forms of activities by the United Nations and other international organizations will continue to expand.

10/ Economic Development of Under-developed Countries: Energy Development; Report of the Secretary-General to the 27th Session of the Economic and Social Council (E/3212).

Economic Development of Under-developed Countries: Petroleum Resources; Report of the Secretary-General to the 29th Session of the Economic and Social Council (E/3324).

New Sources of Energy and Energy Development; Report of the United Nations Conference on New Sources of Energy, 1961. United Nations publication, Sales No. 62.I.21.

11/ A number of seminars and meetings were organized both by the United Nations and its Regional Commissions. A first specific attempt to train administrators who are not technicians was made at the Inter-regional Seminar on Techniques of Petroleum Development, held at United Nations Headquarters from 23 January to 21 February 1962.

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NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

AN APPROACH TO A MINERAL RESOURCES DEVELOPMENT POLICY IN DEVELOPING COUNTRIES

by

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INTRODUCTION

1. Among the various categories of natural resources, minerals are distinguished by four physical and two economic characteristics.

2. The outstanding physical characteristics are that: (a) minerals are non-reproducible and, consequently, mineral deposits can be physically depleted;1/ (b) minerals are non-perishable; the economic implication being that mining operations can be flexible since the minerals can be left underground whenever demand slackens; (c) minerals are difficult to discover, though the difficulties in finding them vary greatly according to the type of mineral sought and the area under exploration. Consequently, exploration is, usually, the most risky part of mineral development; (d) there are many known minerals, currently about 1200, and the list increases every year. While the majority are not of any economic significance now, and some probably never will be, rapidly advancing technology creates new needs elevating neglected minerals to a position of prominence.

3. The two outstanding economic features are:

A. A mineral deposit is a capital asset

4. Once an economic mineral deposit has been found, it represents a capital asset - an addition to the known wealth of the country. Correspondingly, the physical depletion of a mineral deposit decreases the known wealth of the country. Statistics of national income and capital formation neither count a discovery of a mineral as capital formation nor is depletion taken into account in computing disposable national income.2/ Therefore, national income and similar economic data do not adequately measure the significance of the mining industry. Similarly, and this is significant for those less-developed countries largely dependent on petroleum

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1/ In a country as a whole and also within one deposit or mine, minerals may also be depleted in the sense of rising cost of recovery, meaning that rising costs due to deeper mining, reduction in ore content, etc., may make the remaining ores uneconomic at least for some time.

2/ See Joseph Barnea, "National Income, Capital Formation and Natural Resources", Kyklos, 1956, No. 3.

and other mineral exports, national income data, as they make no provision for depletion, may hide a real consumption of wealth. In all old mining areas, in developed as well as under-developed countries, there are abandoned mines and often also ghost towns, once flourishing, but now deserted because the deposits on which they were based have been worked out.

5. Furthermore, the economic significance of mining cannot be satisfactorily measured by the employment it provides, because labour intensitiveness varies among minerals; it is very low, for instance, in petroleum and natural gas production but much higher in metal mining. The economic significance of mineral production depends not only on the mineral, but also on its location and the structure of the economy of the country in which the mineral deposit is found. Generalizing, one can classify the economic significance of mining in less-developed countries, as follows:

(a) earner of foreign exchange;1/

(b) raw material for manufacturing industry, building and construction industry, industrial diamonds and other minerals for cutting, etc., fuels and natural steam for energy production, underground water for many purposes, salt and other products for food and basic chemicals, radioactive minerals for various purposes, mineral springs and many minerals for medical purposes and medicines, diamonds and other precious or semi-precious stones for jewellery and finally, gold, still the primary financial asset, the basis and backbone of all strong currencies;

(c) mineral exploration and investment often is the pioneer and vehicle of development of neglected, uninhabited or inaccessible areas. Frequently it is the exploitation of minerals alone that provides the economic basis for the construction of roads or railways. In desert areas, for example, while many oases are to-day decaying because the slow camel transportation is being replaced by trucks, other new settlements are being established for the exploitation of minerals. Mineral development is, therefore, frequently the catalyst, as well as the basis for new development.

B. Mining is capital intensive

6. Mining, in general, is capital-intensive, though there are considerable differences according to (a) the type of mineral; (b) the type of mining, (c) need and type of processing and (d) need and type of transport facilities. Annex I shows for a few categories of minerals, the differences in investments among the various stages. As will be seen later, the relationship between the various stages has a decisive bearing on the economics of mineral development in developing countries.

1/ It is of interest to note that minerals have played a leading role in foreign trade since the early days of international commerce. Moreover, the now industrialized countries used to be important exporters of minerals and even today, petroleum is the main export commodity of the Soviet Union and the U.S.A. is a substantial exporter of coal, sulphur, phosphates, molybdenum and potash.

CHAPTER I

THE PRE-CONDITIONS FOR MINERAL DEVELOPMENT

A Proper Mining Law

7. Without a mining law, no mining rights can be established and few private investments in mineral exploration or development can take place. A bad mining law is, however, worse than no mining law because it may establish rights without any corresponding duty to explore and develop minerals, while, at the same time, such rights may prevent others from doing so. Too many less-developed countries still have inadequate and outmoded mining laws such as the old Spanish law in many Latin American countries, Islamic laws in some Moslem countries, etc. A modern mining law is a pre-condition for a healthy mineral development.

Basic Geological Information

8. Mineral development on a rational basis cannot be carried out in the complete absence of geological information. Though the degree of detailed geological information required at a certain stage depends primarily on economic factors there is a certain amount of basic geological information which is important and which is needed at the outset before any money is spent on exploration. The costly time-consuming and old-fashioned methods of geological mapping carried out by sturdy geologists exploring the terrain on foot can now be replaced by photogeology in most cases. Photogeology is based on the proper interpretation of aerial photography, a practice which is now quite common and which should be carried out in all developing countries because such photographs have multi-purpose uses. Photomosaics and photo-geological maps will generally provide sufficient general geological information to permit selection of areas with the highest potential for economic discoveries. The proper safeguarding of photogeological maps together with other relevant information such as geological reports, samples of minerals collected, data obtained through core drilling, etc., should be concentrated in one national bureau so as to have somewhere a central inventory of the country's knowledge of geology and minerals. Unfortunately, there are still countries in which such a central inventory does not exist. A repository of basic geological and mineral information of this type will normally be located in a geological or mineral department of the Government. The minimum tasks and the minimum size of such a Government Department will be discussed in the following section.

An appropriate government service

9. A government geological and mining service is an institutional requirement for any independent country, large or small, whether it is already a "mining" country or not. The size of the service will naturally depend on the size of the mining industry and the size of the country. However, even the smallest country cannot afford not to have a small office in which the government can centralize the geological and mining information which is available and through which the government may keep itself informed on national developments in this field. If such an office does not exist then it is probable that geological, hydrological and mineral exploration data acquired by private companies or even by government development companies is not safeguarded and consequently valuable knowledge may be lost. Moreover, as governments have to take an increasingly active part in providing the framework of knowledge on which investments and similar decisions concerning mineral development can be based, a government geological and mineral service will gradually have to assume greater tasks and wider functions.

10. In some of the industrial countries, a sharp distinction is made between geological institutes and mining departments. Experience has shown that in developing

countries, it is unnecessary to have such separation and that a combined geological and mining service can avoid inter-service rivalries and minimize government expenditure. However, as soon as a government decides to undertake the development and operation of mines it is advisable to view this function not as a Government service but as a business operation which should be managed by an autonomous public mining corporation or government development agency.

11. Experience has shown that wherever there is no government geological survey or mining department, the government cannot be active in the field and in these cases one frequently finds that the growth of a mining industry is considerably retarded.1/

The need for a long-term mining policy

12. The acquisition of geological knowledge and the development of mining is a long-term process which can easily be disturbed by frequent changes in government mineral policy. For example, a government may decide to finance the development of a mine but, in so doing, it must be able not only to underwrite the necessary expenditure for one year but to make provision for the financing of such programmes over a considerable number of years. The opening of an underground mine which has to stop because of shortage of money during development may not only endanger mine workings but may also, through postponement of production, lead to substantially increased costs. Similarly, an exploration programme interrupted in the middle may fail to produce any conclusive information on which further action may be based and therefore, the funds invested may remain unproductive.

13. In those cases where a government has decided to leave some or all exploration and development of minerals in private hands, such a decision will only lead to investment if a "climate" exists in which the policy decision by the government is regarded as a long-term policy not subject to frequent changes. Experience has shown that a long-term mining policy is of crucial importance for development of a mining industry in less-developed countries.

14. This statement should not be interpreted as meaning that a decision to allow private capital to explore for and develop minerals on the basis of a modern mining law, will be sufficient to bring about large-scale investment in exploration and development, because actual investments will also depend on a number of related and inter-locking questions such as the prospects for finding economic mineral deposits, locational aspects, potential markets and other questions. In some circumstances, in addition to a long-term mineral policy, the government may have to take certain other steps designed to provide inducement and incentive. What is certain, however, is that without an established and clearly understood mineral policy, even the additional steps and measures taken by the Government are not likely to produce significant results on a long-term basis.

1/ En passant, it may be mentioned that the Special Fund will not accept a project for mineral exploration unless the country possesses a geological or mining service, even a small one, capable of continuing the work begun with United Nations funds.

CHAPTER II

ELEMENTS FOR A SUSTAINED MINERAL DEVELOPMENT POLICY

The variety of conditions in mineral investments

15. In the Introduction, attention was drawn to the 4-stage character of practically all mineral developments, namely, exploration, extraction, processing and transportation.1/

16. Each stage has its own problems with attendant investment requirements and the variations between these requirements are of great importance for developing countries, but of far less importance for industrialized countries with well developed infrastructures. The table in Annex I shows, for instance, that for gold and diamonds, exploration costs are either low or medium high and extraction costs might be either low, medium or high. But processing and transportation costs are relatively minor or even negligible. Consequently, these are the minerals for which to explore in landlocked countries with no transport facilities. Countries such as Chad, Niger, Upper Volta, Afghanistan and others far from the coast and with limited transport facilities, could, at a relatively low cost, develop valuable export industries if they concentrated on such minerals, assuming their existence in economic quantities.

17. Industrial minerals such as potash and other salts may, if available in surface deposits, require only medium investments in practically all stages and may, therefore, be easier to finance in many developing countries than metallic minerals which call for high investments and costly processing facilities, unless unusual location advantages and high-grade deposits allow the export of direct shipping ore.

18. These few examples indicate that the variety of the investment requirements of minerals must be taken into account in studying the possibilities in a given country. This applies not only to mineral development but also to the planning and implementation of exploration programmes which should be designed to fit the total picture - geological, geographic and economic.

19. Most of the minerals processed for immediate local industries use such as clays, glass sands, gypsum, building stone, etc., have moderate exploration costs and low extraction costs if open-cast methods can be applied. In a mineral development programme therefore, such minerals should not be neglected if the establishment of local industries is also envisaged.

20. The table in Annex I indicating the various stages of mineral development is obviously insufficient, for a considerable number of minerals, when decisions on investments and processing facilities have to be made.2/ The processing of some minerals, such as bauxite and most other metallic minerals, is energy-intensive. Consequently, processing of such minerals should only be considered if low-cost energy resources are available. Conversely, if low-cost energy resources are available, this may constitute a strong reason for giving priority to exploration for those minerals which require energy-irtensive processing facilities.

21. These general recommendations will, for their practical application, have to be supported by far more detailed studies concerning the costs of producing and transporting minerals, existence of potential markets, etc. It cannot be overemphasized that such fact-finding analyses are an essential prerequisite to any investment programme.

1/ In some cases, minerals are simply extracted and used locally, thus avoiding processing and transportation.

2/ The availability of labour, capital and other factors of production are assumed here.

Investment in knowledge

(a) Geological knowledge:

22. It has been pointed out earlier that the availability of geological information is a pre-condition for almost all mineral development. All mineral exploration involves an element of risk, but this risk can be substantially reduced in many cases by the early availability of sufficient geological and geophysical information. Governments in developing countries, therefore, have to assume greater responsibilities in providing the infrastructure of geological knowledge necessary before any detailed exploration programmes are undertaken. Nowadays, the infrastructure of information can be obtained in a relatively short time through photogeology and airborne geophysical surveys. By providing geological maps based on photogeology and geophysical data based on airborne geophysical surveys substantial information will become available for the preparation of an exploration programme. In countries where private interests, local or foreign, are allowed to explore for minerals, the availability of such information will act as a stimulant for investments in exploration. There is no hard and fast line between the collection of basic geological information and exploration. Thus in certain countries, and in certain circumstances, wherever the infrastructure of information provides strong indications of the availability of minerals of considerable economic significance, a government may decide, in the absence of private capital, to commence exploration activities by investing funds in the first stages of exploration through pitting, trenching and test drilling.

23. While developing the infrastructure of knowledge, namely geological mapping and other relevant information, is quite expensive, it is nevertheless now accepted as a task of governments. For this reason, the Special Fund is willing to participate in the cost of mineral surveys, and has already done so in about 30 countries.

24. In programming the geological infrastructure it is obviously impossible, in most countries, to cover the whole country. Therefore, preference should be given to areas which show indication of mineralisation and which either possess certain transport facilities already or are so located that these could be provided with relatively small investments. Correspondingly, areas which are inaccessible and for which government development programmes do not provide for the construction of transport facilities in the near future, should be the last areas for which the geological infrastructure is provided.

25. Expensive as this infrastructure of geological knowledge is for the budget of developing countries, the sums involved are small compared to the capital requirements of detailed exploration programmes, at least insofar as fuel, metallic and some industrial minerals are concerned. For this reason, funds for an intensive exploration programme will need a much closer economic analysis and justification than the approval of funds for the infrastructure of geological knowledge.

(b) Laboratories:

26. An active geological programme requires laboratories for mineral testing and follow-up exploration, and mining activities require various other laboratories. At an early stage therefore, governments must be aware that the scientific infrastructure required for a mining country or for a country which hopes to develop a mineral industry, calls for the establishment of a series of laboratories for analyses and testing. Such laboratories, in order to serve not only government services but also large and small mining companies, prospectors, and operating mines, should preferably be government owned and attached either to mineral institutes or to a university. It is also essential that whenever laboratories of this kind are established, they should be staffed by competent experts with modern equipment, because a laboratory which cannot provide reliable testing is worse than no laboratory.

27. The timing and type of laboratories required in a country will depend on the stage of economic development of the country as well as on the geological and mineral conditions.

(c) Human skill:

28. It is not sufficient merely to provide for the teaching of geology, mining, analytical chemistry, ore dressing and associated sciences at local universities or abroad; what is more important, is to provide favourable conditions of employment and a professional climate which will allow trained people to remain up-to-date in their profession. This first requires a salary level which makes such professions attractive in order to prevent the best-trained people from turning to more lucrative pursuits or even leaving the country for better-paid jobs abroad. It is also necessary that experts have sufficient funds to subscribe to professional journals, to attend, from time to time, international conferences and to visit mines and institutes abroad. Such investment in human skill, though recognized by most people as essential, nevertheless runs into considerable difficulties as the payment of higher salaries to geologists, mining engineers, etc., tends to disturb the salary structures of government service. Experience has shown that this problem can be solved by the establishment of geological and mineral institutes which, though owned by the Government, are, nevertheless, separated from Government service and enjoy a special status including higher salary scales. If developing countries do not find ways of retaining their highly skilled local personnel with adequate salaries, they will have to employ foreign experts at much higher cost.

Government mining corporations or agencies

29. A number of developing countries have set up government agencies in order to operate mines and mineral processing plants. There is no general judgement one can render on such agencies. Indeed, in some situations, when private capital is not willing to develop these minerals, the government may have no choice but to invest its own funds if the development of such mines is regarded as a matter of priority by the government. It should be borne in mind, however, that if private capital is forthcoming for other investments (and the government is willing to allow private capital to invest in minerals) the reluctance of capital to develop such mines might be due to a difference in the economic evaluation of such mineral deposits. Nevertheless, there are a number of cases where, from the overall point of view of the necessity of economic development, the government may have no choice but to invest its own funds in order to develop certain mines. U.N. experience has shown that only in a relatively small number of cases have government-operated mines been worked successfully. It is essential, therefore, to know something about the basic reasons for failures in order to avoid common mistakes.

30. First of all, a government deciding on a mineral development must know that a mining operation is a commercial enterprise and cannot be carried out within the framework of a civil service and of a government budget. Such operation should, therefore, be carried out in a separate business organization owned by the government but not subject to civil service regulations. The mine manager must have full authority; otherwise he may have to ask the civil service for authority for each purchase of spare parts or for the employment of workers, for example, and the operation will surely be a failure. In addition to the separation of the mining operation from the work of geological and mineral services, it is also essential that the managerial positions be filled by competent people and not by politicians, that the mining management starts with sufficient funds and that it has full authority as regards all operations of the mine. There are government-owned and operated mines not only in the centrally planned economies but also in Western Europe and quite a number of them are successful business enterprises. However, if one analyses the reasons for the success of such mines, it becomes apparent that it is due to an efficient, competent and independent mine management, to a good mineral deposit and to isolation from political interference. Countries which do not

possess sufficient competent personnel to operate mines would therefore have to rely on foreign experts and, if this is undesirable, such countries should carefully review the situation before they decide on government management of mines.

Diversification

31. The development of a large mineral deposit for export is usually easier than the simultaneous development of different minerals for export as well as for local industrial and other use. A large deposit of an economic grade and/or one which is relatively well located, may justify the establishment of specific means of transport such as railways or pipelines, and the export may yield foreign exchange in a relatively short period. This type of development, in which international companies have had much experience, is usually of undoubted benefit to the country. However, in many cases, the economy of a country is developed around one single mineral product, and variations in price and other market conditions for this one mineral will have a widespread effect on the economy of the country as a whole. In this category one finds petroleum export countries, iron ore and copper export countries. It is obvious that a single-mineral economy is not a healthy long-term structure for any country. Nor is it in most cases a necessity created by nature. It has already been pointed out in the Introduction that there are very many minerals and therefore diversification in mineral exploration, development and production as a considered policy would often allow the avoidance of a single-mineral product development. Such a policy however, can only effectively be applied if the government provides the necessary geological infrastructure and other facilities, if necessary, for the exploration and development of other minerals. It is also imperative that possibilities of local utilization of minerals for industrial and other purposes are borne in mind from an early stage and that attempts in this direction are supported on a long-term basis. In practically every country, even the smallest ones, there are possibilities of developing several mineral-based industries such as glass-making, ceramics, cement and other building industries and some other industries including a few chemical industries. Countries which are today in the position of a single mineral production economy should pay special attention to this problem and accclerate their efforts towards diversification of their mining sector.

CHAPTER III

SOME SPECIFIC PROBLEMS IN DEVELOPING COUNTRIES

32. Small-scale mining

Small-scale mining still exists in a number of developing countries such as Chile, Burma, Pakistan, Philippines and Bolivia. In practically all cases, small-scale mining represents the backward, or even primitive, sector of the mining industry. Too often small mines are operated without any mechanical equipment, and without any technically competent advice on mine design, methods of production, etc.

33. As small mines can operate profitably if they are operated by professionally trained personnel and use up-to-date methods of production, there is no reason to assume that, under all circumstances, only large mines are the advisable economic form of mineral exploration in developing countries. In many cases, mineral deposits are small and large international mining companies are neither interested nor capable of operating such small mines on a profitable basis. Nor are government agencies, as a rule, in a position to manage small mines effectively. In such countries, therefore, where international companies and government agencies cannot operate small mines but where small mineral deposits exist, the government has the choice, either of disregarding small mineral deposits and, wherever primitive small-scale mining still exists, of allowing such mines to die out gradually; or it has the choice of assisting in the modernization and, if necessary, also in the financing of small mines by providing technical assistance in planning and operating the mines, in training personnel and, if necessary, also in financing the purchase of equipment and marketing of ores.

34. United Nations technical assistance provided in some cases to such mines has indicated that in a number of countries, small-scale mining, if properly modernized, can make a valuable contribution to the economic development of the country. In one country it was found that coal mining was carried out on a small scale because coal deposits were small and dispersed, although the coal itself was of a high quality; production was declining year by year and the industry was regarded as a dying one. A United Nations coal mining engineer sent to that country found that, with the introduction of new methods, coal mining costs could be lowered very considerably and output increased substantially. He also found that there was not a single experienced coal mining engineer in the country, and the complete lack of technical knowledge in the field was the decisive reason for the decline of this industry. Similar experiences have been encountered in other countries. In some cases, it was found that the mining law allowed the establishment of mines of such limited size that mines could not develop the long-term reserves required for rational planning and efficient methods of extraction. These and other weaknesses can be overcome and, in many cases, small-scale mines can make a valuable contribution to the mineral production of a country, often at low cost.

35. It is essential, therefore, that in any economic programming due attention be paid to the possibilities of small-scale mining and its appropriate place in future mineral production.

Rehabilitation of neglected mines

36. Connected with the question of small-scale mining, although not identical, is the question of the rehabilitation of closed or abandoned mines. In the past, almost all valuable minerals produced in developing countries were largely, if not exclusively, exported, and often only high grade ores were developed. When the high grade ores were mined out, mines were closed or abandoned. To some extent, this applies also to mines of earlier historical periods. Technology of extraction and

processing is a dynamic field in which advances and changes in technology are constantly taking place. Some mines closed down 50 to 60 years ago because the low grade reserves were at that time uneconomic may now be profitably worked due to technological improvements.

37. As a rule, it is less costly to rehabilitate neglected or abandoned mines than to explore for new mineral deposits, opening new mines, etc. It is true that the rehabilitation of neglected or abandoned mines may require a higher technological competence and may pose more complicated technical questions than exploration; nethertheless, it is advisable that government mining departments keep under periodic review the information which should be available in their files on abandoned and neglected mines. The rehabilitation of a mine can usually be effected in a short period of time, measured in many cases, in months rather than years. Therefore, vigilance should be exercised in order to take advantage of short term fluctuations in mineral prices.

38. Connected with the question of rehabilitation of abandoned and neglected mines is the timely study of the technology of treatment of lower grade ores before the higher grade ores are fully worked out. If this is done, the closing of mines can be prevented and the social and economic disturbances created by such closing be avoided. In one country where a large mine employing thousands of workers and representing an important earner of foreign exchange is approaching the exhaustion of its high grade ores, a U.N. expert has drawn the attention of the Government to this problem. The proving of sufficient tonnage of low grade ores plus the development of efficient treatment of the lower grade ores are now the subject of a Special Fund project. It is hoped that this project will not only lead to a very considerable extension of the life of this mine and to the expansion of its activities, but also that it will result in the establishment of a mineral processing plant in the country, which happens to possess cheap hydro-electric power.

39. In other cases, U.N. experts have studied abandoned mines and sometimes found that by application of modern technology, these mines can be rehabilitated. However, a word of caution is advisable here. Governments should not indiscriminately view all abandoned mines as potential assets. Some of the operators of yesteryear, e.g. the Spaniards in Colonial America, were amazingly efficient in maximizing recovery of even low-grade minerals.

Mining in Dry Areas

40. A considerable number of developing countries suffer from a shortage of water and a large percentage of the known mineral deposits are located in deserts or semi-arid areas. Thus, there are difficulties in obtaining sufficient quantities of water not only for mining operation but also for concentration as well as for the personnel and their families living nearby. In a number of cases, the lack of water has prevented the development of very interesting mineral deposits. In other instances, for example in some mining areas in the Middle East, water is rationed. What is needed, therefore, is the development of dry processes instead of wet concentration for mines in water-short areas. During the last few years, a sensational advance has been made in this direction and a considerable number of processes have been developed. Some of these show such general advantages that they are even introduced in areas where there is no water shortage, such as Canada. However, at the moment, it appears that the knowledge of this latest development has been little disseminated in developing countries. Broader diffusion of knowlegde and further work in this field would allow not only improved living conditions and lower mining cost, but may also permit the development of mines in desert areas. There is no system of mechanism by which information regarding newly available techniques can be brought quickly to the attention of the developing countries. However, when and wherever U.N. experts are requested by governments to look into this problem, such experts have drawn attention to such methods. It is hoped that, in the near future, the U.N. will be able to organize a seminar on dry mineral processing methods in developing countries.

The Growing Needs for Ore Processing and its Implication for Developing Countries

41. In general, only well located higher grade ores can be developed for export. Where very little exploration has so far been carried out, there is still hope of discovering new high grade ore deposits, which are well located, but the time is approaching when almost all easily found and rich deposits will have been developed. Of the present iron ore reserves in the world, it was esti ated, for the year 1960, that only one third was direct shipping ore. Therefore, two-thirds needed beneficiation before they could be shipped or locally consumed (1)

(1) Bruce C. NETSCHERT and Hans H. LANDSBERG "The Future Supply of the Major Metals", Resources for the Future, Washington D.C., 1961. Table 2, page 20.

With many minerals, the technology of concentration, progressively advancing over the years, has allowed the utilisation of ores with a steadily decreasing mineral content, in the case of copper, the average grade of ore mined in the United States has decreased from 3% in the 1880 to 0.8 for the average of the years 1951-1956 (2). Similar data are available for a number of other minerals.

42. The decrease in grade of an exploitable mineral means one thing for the developing countries; namely that the ore in its unprocessed state, cannot be shipped and therefore must be concentrated near the mine. Consequently, on a long term basis, developing countries have to foresee the increasing need for efficient treatment processes. This recognition in itself will lead to a number of consequences. The whole field of mineral processing technology is becoming increasingly important and this technology, sooner or later, will have to be acquired by all countries in which the mining industry plays a considerable role. In the developing countries, this will call for the establishment of additional laboratories and for an expanding university research programme to undertake applied research on a day-to-day basis for quickly and efficiently solving problems which plague the mining industry. It will also call for a whole series of economic studies on the relationship of investments, not only in the treatment facilities themselves, but also in related energy, water and similar facilities.

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(2) O.C. HERFINDAHL "Copper Costs and Prices : 1870-1957", Resources for the Future, Baltimore : John Hopkins Press, 1960, page 224.

CHAPTER IV

THE NEED FOR INTERNATIONAL CO-OPERATION

(a) Regional Co-operation:

43. It is difficult for small developing countries to set up and finance properly staffed geological and mining agencies, laboratories, training institutes, etc. It may be advisable therefore for smaller developing countries to set up joint facilities for map making and geological studies, central laboratories, central training facilities, etc. In Western Africa, such co-operation is now under discussion, and it is a policy of the Special Fund to give full support to regional institutes, provided the need and the full co-operation of the Governments concerned can be clearly demonstrated to the Special Fund. This field of regional co-operation is one in which essentially, the initiative will have to come from the Governments themselves. If such co-operation can be brought about, support from international organizations will usually be forthcoming.

(b) Multi-lateral Technical Assistance:

44. The United Nations is providing developing countries, under its Technical Assistance Programme, with experts in the whole field of mining. Under this programme, about 200 experts, essentially as advisers, are provided each year to developing countries. All relevant professions are involved, from exploration geologists to ore dressers. Such experts stay in the country and work with the Government department concerned for short or long-term periods, as desired by the Government. The United Nations also provides, under its OPEX Programme, a limited number of U.N. experts who become Government officials in executive functions. The funds available under the OPEX Programme allow the appointment of only a small number of experts each year.

45. Finally, the United Nations executes for the Special Fund a considerable number of projects concerned either with mineral surveys or with the establishment of geological and mineral institutes. In all such projects, the United Nations carries out the project under its own responsibility through a Project Manager who is a United Nations official and who is assisted by foreign as well as by locally appointed experts. The project is carried out with full co-operation of the Government. Most of the projects cost more than one million dollars and are financed by the Special Fund and by the Government concerned on a fifty-fifty basis. The United Nations also provides fellowships under its Technical Assistance programme as well as under Special Fund projects for further training of local personnel abroad.

(c) Bi-lateral Assistance:

46. Bi-lateral assistance in the field of mining is provided by most of the industrial countries and even by some of the developing countries to other developing countries. A full description of these programmes cannot be provided here.

(d) Other International Contacts:

47. There is a number of international professional organizations which hold regular conferences and issue journals which provide means for technical personnel in developing countries to maintain professional and personal contacts on an international basis. Governments in developing countries should provide facilities for its professional staff to maintain such contacts in every way possible.

ANNEX I

INVESTMENT REQUIREMENTS FOR SOME REPRESENTATIVE GROUPS OF MINERALS ACCORDING TO THE FOUR BASIC STAGES OF DEVELOPMENT

	Petroleum	Coal	Metallic minerals	Industrial minerals	Building materials	Precious metals		Diamonds	
						Alluvial	Underground	Alluvial	Underground
Exploration	high	medium	medium	medium	low	low	medium	low	medium
Extraction:									
Underground	high	high	high	high	-	-	high	-	high
Open cast	-	low	low	low	low	low	-	low	-
Processing	high	low	high	medium	low	-	low	-	low
Transportation 1/	medium	high	medium	medium	high	low	low	low	low

1/ Per unit of value.

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NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

G E O L O G I C A L S U R V E Y A N D E V A L U A T I O N O F M I N E R A L R E S O U R C E S I N U N D E R - D E V E L O P E D C O U N T R I E S

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a) Specific natural conditions

1) Most of the economically under-developed countries which passed through a long period of colonial rule, have considerable mineral resources. Assistance in the survey and evaluation of these recources is given by the socialist countries within the scope of economic agreements on assistance to these countries.

It is granted largely in the form of expert cooperation of specialists who direct or help in geological research, in training specialists and in designing and constructing mines.

2) Geology is of special importance for the development of economically under-developed countries because it is the first condition for development of the key branches of economy and technology. Geological research and survey provide minerals for the most important branches of industry which, of their production exceeds local consuption, are often a very advantageous means for international trade. Geological surveys ensure the first prerequisites for the utilization of rivers as a source of power and for irrigation, the basis for the utilization of ground water and providing raw materials for building.

3) Insufficient knowledge of the geological structure of vast territories, progress in geology by the advanced countries and the new attitude to aid to under-developed countries arising from the mission of the United Nations, calls for a new method of geological research.

Only general knowledge is available of the geological structure of the under-developed countries. No modern systematic geological mapping was done in many of these countries. For this reason initial geological survey in the form of aid described above is at first

usually conducted by expanding old and established deposits or confirming other mineral deposits. This is a quick way of obtaining the basis for planning new or extending existing mines and processing plants.

It would, however, not be corrected to concentrate only on prospecting for the various raw materials according to their immediate possibilities on the world market and on supplementing knowledge on deposits which are partly explored. A systematic complex survey and geological mapping of whole areas should be started at the same time with a view to the most urgent needs of the economy. Very good and often unexpected results are achieved by this system of work.

Geological survey is often complicated by the difficult accessibility of the terrain and a lack of topographical information. As the result basic topographical and subsequent geological mapping is usually very costly. In spite of this, however, even in the first phase, work should be aimed at systematic geological-topographical mapping of the entire area under exploration, which is essential for further geological survey, projecting of new sources of minerals and for all economic and technical considerations.

In this all available technical means which speed up and make regional geological exploration and mapping more precise should be used as widely as possible, especially aviation (aero-geophysical measurings, aero-photopraphy, etd.)

A large number of under-developed countries have some specific geological difficulties which complicate exploration of mineral deposits. The first is the extent of wind-swept earth and sand and the dense vegetation. Specific utilization of bio-chemical and metalo-metric methods should be elaborated for different cases.

A thorough geological survey requires material and technical, especially mechanical equipment, of the groups of geologists. The engineering industry in those countries is usually not at a level where repairs or manufacture of spare parts could be undertaken without holding up research work. For this reason there must be adequate spare parts for the machines used.

In the scope of systematic regional geological research it is useful to ensure engineering and geological research of the utilization of rivers, especially for power and irrigation projects. Where the necessary material is lacking it is appropriate to start hydro-geological and geomorphological research of the main rivers.

b) Political and economic conditions

1) The main principle in organizing assistance in geological exploration is the ratio and position of foreign experts. It is not effective or correct, especially with big expeditions, to select only foreign experts for leading the expeditions. On the contrary, an effort should be made to bring about cooperation in research teams composed of both foreign specialists and local experts from the point of view of the nationality policy. In this of course the basic line, i.e. that the group is capable of executing even the most urgent tasks of complex research in a given time should be observed.

The work of the teams should be directed so that research work may be gradually transferred to local experts and foreign participation confined to regular and later to only occasional consultation.

2) The observance of these principles makes it necessary to ensure education (school and post-graduate) of local workers within a required period and to the required extend; first at foreign and later at local schools and research institutes. Basic specialized schooling of the local research workers concerns geologists as well as technicians. Schooling is sometimes combined with great difficulties, especially from the point of view of expert translation in the local language. Very often the translator is not a specialist and the lecturer does not know the local language, terminology is often lacking in the language concerned, so that the quality of the translation is not guaranteed. In spite of this however, this schooling must be carried out even at this risk in order to make assistance in geological research successful. Our experience is that thorough schooling of a small number of the most intelligent of the local collaborators is the most successful; they then conduct cources on a broader scale. It is more advantageous because with a small group much closer personal contact between the lecturer and his students and detailed explanations are possible.

3) The results of geological research should be put into practice by technical means in the construction of the necessary mining, washing and grading and processing installations in order that a maximum part of the production processes dependent on minerals be

performed in the country in which they are found within the shortest possible time.

c) Experiences of The Czechoslovak Socialist Republic in the field of Geological Research in The Vietnamese Democratic Republic

In conclusion we cite the experience of the Czechoslovak Socialist Republic in extending assistance to the Vietnamese Democratic Republic, characterized by certain conditions.

1) Close attention should be devoted to specific local natural conditions which influence the choice of working methods and the effectiveness of the work. In the VDR, this was so with zinc-lead ores of special formation. The difficult geology and tectonics was clarified only after detailed geological research. In the Cho Dien basin, for instance, the French mining company did not know of the existence of large ore deposits over which we and they were literally walking in our expeditions. That was caused particularly by the dense tropical vegetation and by the fact that this type of ore formation in such large dimensions is not common. In all basins where Czechoslovakia helped Vietnamese geological exploration, ore had already been mined by French companies. Their purpose was to find the richest veins of those deposits. In consequence of inadequate geological supervision and sometimes wrong geological conclusions, some very rich sections remained unexploited in this way. That is why large deposits were newly confirmed even where according to old French reports, the deposits had already been exhausted. Some rich mines are thus so badly devastated by poorly planned mining that it will not be possible to work them again.

Because the former capitalist mining companies in the VDR did not have enough finances which would have enabled them to extract poor grade ore that can be processed economically today, the regular method of prospecting for new deposits can be applied. Only the richest zone of the deposit near the surface which had the maximum content of useful components was extracted.

2) The fundamental prerequisite for conducting geological research in under-developed countries is the principle "quick and cheap". That is why it is necessary that light and inexpensive types of research projects are chosen. Large ore deposits in the VDR were confirmed by means of picks and hand drills. This method and simultaneous geological mapping enabled the fultiment of the

main task, i.e. to confirm the necessary deposits fo the construction of a mine quickly and cheaply.

3) In view of the specific political situation in under-developed countries close cooperation with local political and economic authorities is necessary. As an example we mention the organisation of people's prospecting in areas where deposits are likely to be found in the Vietnamese Democratic Republic. The polupation in the particular region were simply shown samples of ores and in cooperation with the local political authorities, popular prospecting was organized which yielded very good results. Economically, surveys organized in this manner were very effective; it should be added that whereever the people discovered indications of deposits, they would never have been teached by foreign specialists.

Close cooperation with local organizations in the VDR also proved successful. In the consgruction of a mine, the practice was adopted that the respective geological research station or section is directed by the local organization in close cooperation with the experts. Responsibility for successful geological research which at the onset is borne by the foreign specialists is gradually transferred to the local workers after their training.

The prnociple of cooperation between the Czechoslovak Socialist Republic and the Vietnamese Democratic Republic in geological research is to extend selfless aid and impart useful experience.

Assistance is extended in accordance with the requirements of the Vietnamese Democratic Republic and expert evaluation of the Czechoslovak specialists concerning the prospects of the various basins. All aspects of research and extracting mentioned in the report, i.e. the geological and economic conditions are carefully considered and premiminary elaboration and study of the deposits, and following consultation with the projecting organizations, proposed for exploration.

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